VALURİNG BY RECYCLİNG OF POLYMERİC WASTE RECOVERED FROM ELECTRONİC AND ELECTRİCAL EQUİPMENT OUT OF ORDER

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Abstract

The purpose of this study is the recovery and recycling of polymeric waste from electrical and electronics equipment out of service (WEEE) and stored in the open of environment.
The high consumption of these equipments and the practice by some manufacturers of the planned obsolescence make this waste take a worrying extent in the degradation of the environment. The addition of the ABS polymer to this waste makes it possible to reintroduce them into the cycle of the production of raw materials by recycling.
we proceeded by adding Acrylonitrile Butadiene Styrene (ABS) at 20, 40, 50, 60 and 80% to the WEEE Matix.
The waste is washed and crushed beforehand and the ABS is used in the virgin state. The mixing was done first cold by placing the various constituents in a cylinder in random rotation, then hot extrusion.
The preparation of the test samples was carried out without additives or compatibilizers by injection process after grinding of the extrusion product. The mechanical characterization of the samples showed that the introduction of WEEE in the ABS matrix generates small variations in the modulus of elasticity. The maximum elastic stress increases by 27% for the mixture (50%WEEE/50% ABS). Resilience also increases with the concentration of ABS in the WEEE matrix and reaches 90% for the mixtures (50%WEEE/50% ABS). Finally, we proceeded to the observation and readings of the fracture facies by scanning electron microscopy (SEM).

Keywords: Environment, polymer, recycling, waste

1. Introduction

Polymeric waste from electrical and electronic equipment out of service (WEEE) is becoming increasingly important in our environment, whose current degraded situation is not without consequence on fauna and flora as well as on public health.
One of the major current issues in relation to the environment is the recovery and recycling of this waste in order to reintroduce it again into the material production cycle and thus contribute significantly reduce the consumption of non-renewable and polluting fossil fuels.
It is obvious that in the face of such a disturbing report on our environment and global warming, numerous and diverse scientific works have been undertaken for this purpose.
The contribution of Yanhong Zheng and al. [1] relates to the recycling of non-ferrous waste from printed circuit boards (PCBs) by using them as reinforcing filler to a polypropylene matrix.
The mechanical tests of resistance to the temperature and concentration of toxic product such as the lead which they led them made them that there is a clear improvement of the mechanical properties of resistance as well as a better resistance to the temperature. They also showed that adding up to 30% of this waste can be added without violating environmental regulations.
Xiaoning Yang et al. [2] have pyrolyzed and dehalogenated plastics from waste electrical and electronic equipment. They have shown that the halogen element in WEEE seriously hampers the rate of recycling and dehalogenation is the key step in all WEEE recycling methods. For the characterization of plastics from DEEs, Elisabeth Maris et al. [3] used medium infrared spectrometry (MIR Mid-infrared spectrometry) to designate each type of polymer, and X-ray fluorescence spectrometry to determine the nature and quantity of flame retardants and fillers.
Since brominated flame retardants in polymers derived from WEEE have been the main obstacle to recycling, Chuan Ma et al. [4] proposed chemical recycling as an environmentally friendly method of recycling for the production of clean fuels or chemicals products.They showed that the integration of pyrolysis with the catalytic upgrade process can provide significant economic and environmental options in converting plastics into useful and valuable materials.
Joana Beigbeder et al. [5] studied the improvement of a NIR sorting device to achieve high levels of purity for three of the most used plastics in WEEE: ABS, ABS / PC and HIPS, with impurity content varying between 5 and 8% by weight.
Gent Malcolm Richard and al. [6] were interested in the density separation of waste plastics with cyclones DMS (density media separation) which is an inexpensive and highly efficient process for the recycling of plastics either for direct use in manufacturing or to prepare fractions for further treatment with other treatment methods.
The work of Elisabete Maria Saraiva Sanchez [7] concerns the effect of aging on the properties of polycarbonate (PC) and butylene terephthalate (PBT) polymer blends widely used in the automotive industry for their temperature stability and impact resistance. They showed good elongation at break after recycling. Modulus of elasticity and tensile strength are not affected by aging. The melt index is affected but without effects on the molding properties. Only the impact resistance is affected. They also showed that some properties are recovered after recycling.
In this context, our contribution to the preservation of the environment through the recycling of polymeric waste is

aimed at the recycling of polymers from waste electrical and electronic equipment (WEEE). The process consists, initially in the recovery, without sorting or selection, carcasses of these equipment polymers that will be milled to form the basic raw material. The second step is to add this waste to an ABS polymer matrix (Acryl Butadiene Styrene) at different concentrations to form the mixtures. These mixtures are then injected to produce tensile and resilient test samples which allowed the mechanical and morphological characterization of each mixture to be carried out. The stress-strain curves are obtained by tensile test. These curves are then analyzed to determine the variation of modulus of elasticity, maximum elastic stress and elongation at break. Resilience tests were undertaken to determine the impact resistance. The microstructure analysis of fracture facies was performed on the images obtained by SEM. A comparative study is then undertaken to evaluate the impact of the ABS concentration in the WEEE matrix on the properties of the mixtures.

2. Procedure and experimental protocol

2.1 Waste recovery and mixing

Polymeric waste is recovered from reformed electronic and electrical equipment and stored in the open in the environment. We considered in bulk all the polymeric components that we mixed, washed and crushed.
We have also chosen to add ABS to the WEEE matrix, whose choice is motivated by the fact that a large part of this waste consists of ABS. After grinding, we added to the WEEE matrix of ABS at concentrations of 20, 40, 50, 60, and 80%. The mixing was done first cold by placing all the components in a cylinder with random rotation, then hot extrusion to form rushes which will be crushed again. These mixtures constitute the raw materials whose mechanical properties will be studied through the samples test that will be produced by injection without compatibilizer or additives. A Scanning Electron Microscopy (SEM) observation of the fracture facies will identify the existing phases and the mode of rupture and corroborate the results obtained during the tensile and resilience tests.

2.2 . Preparation of samples test.

Standard tensile and resilient samples test are realized by injection process. The parameters of the injection machine are summarized in Table 1.

Table 1. parameters of the injection machine

<table>
<tr><td colspan="5">Temperatures</td></tr>
<tr><td>Alimentation</td><td>Plastification</td><td>pumping</td><td colspan="2">spinneret</td></tr>
<tr><td>180 C°</td><td>200 C°</td><td>220 C°</td><td colspan="2">250 C°</td></tr>
<tr><td colspan="5">pressure</td></tr>
<tr><td>Injection</td><td>retention</td><td colspan="3">Against pressure</td></tr>
<tr><td>100 Bar</td><td>80 Bar</td><td colspan="3">16 Bar</td></tr>
<tr><td colspan="5">Time</td></tr>
<tr><td>Injection</td><td>retention</td><td>Cooling</td><td>Opening the mold</td><td>Closing</td></tr>
<tr><td>1,5 s</td><td>2,8 s</td><td>16 s</td><td>1,0 s</td><td>0,3 s</td></tr>
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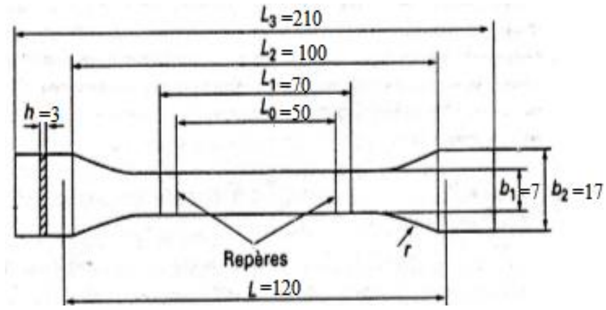
2.3 Traction samples test

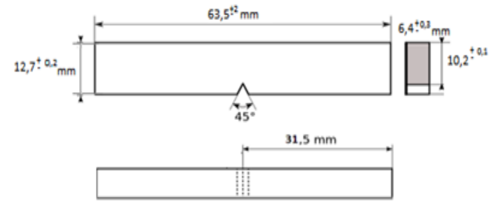
The geometry and dimensions of the tensile test pieces (Diagram 1) were carried out in accordance with the NF EN ISO 527-2 standard. The traction speed is fixed at 10mm / min.



Scheme 1 Geometry of the tensile samples test according to the NF EN ISO 527-2 standard

2.4. Resilience samples test

In the case of the Charpy samples test (V-notch) (Schem 2), their geometry and dimensions were carried out according to the standard NE 3.03.070 according to Method 3A. We used a ZWICK 5102 pendulum sheep according to DIN 51222



Scheme 2. Geometry and dimensions of the resilience samples test

3. Results and observation

3.1 Stress-strain curves

The tensile tests are carried out on five samples of the same mixture. With errors that are of the order of 11.7% for the elongation and 9.9% for the maximum elastic stress, Figure 1 shows well that there is globally repeatability of the results. The absence of the plasticity plateau is also very visible. These results concern tensile tests on the samples of the 100% WEEE mixture.

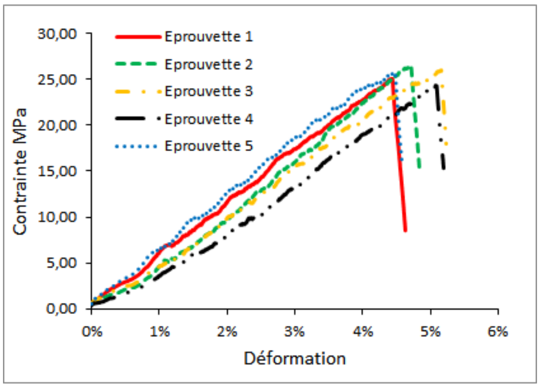


Fig.1 Repetitiveness of the tensile test of the samples 100% WEEE mixture

Figure 2 shows the results of the tensile tests on the samples of WEEE / ABS mixtures.

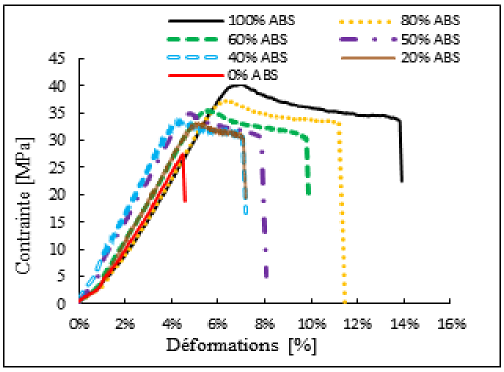


Fig. 2: Stress-strain curve of WEEE / ABS mixtures with different concentrations of ABS

The results of the tensile tests show (Fig.2) that the addition of ABS at different concentrations to the WEEE matrix results in the improvement of the strength and ductility properties of the mixtures. We observe that WEEE has a fragile behavior and that the addition of ABS to WEEE / ABS blends reveals a plateau of plasticity which increases with the increase of ABS concentration.

3.2 Resilience Test

Figure 3 shows the results of the resilience tests. The increase in impact resistance is noted with the increase of the concentration of ABS in the mixture WEEE / ABS.

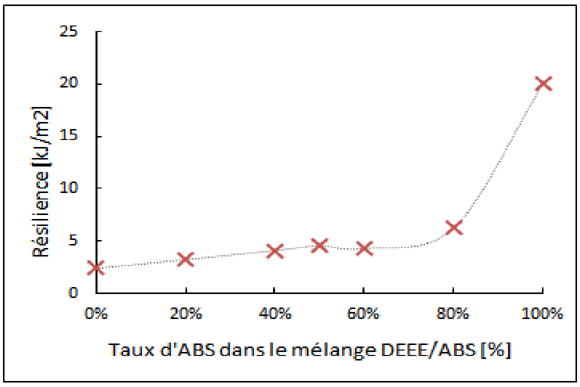


Fig. 3: Variation of the resilience of mixtures according to the concentration of ABS in the WEEE matrix

4. Analysis and evaluation of the results

4.1 Mechanical characterization

4.1.1. Modules of elasticity

From Figure 2 the elasticity modules for the mixtures are extracted and shown in Figure 4.
There is a small variation in modulus of elasticity for all ABS concentrations in the WEEE matrix.

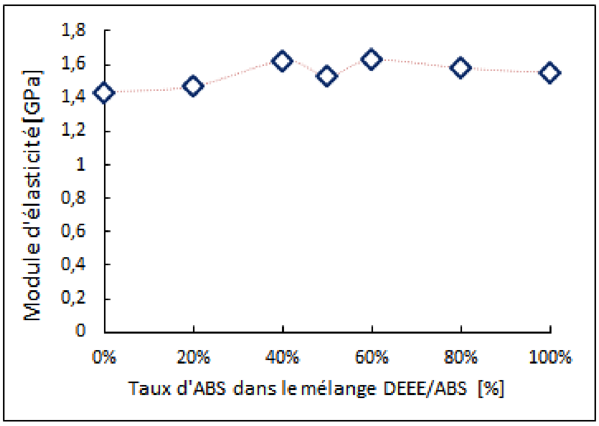


Fig. 4. Variation of the modulus of elasticity of the mixtures according to the concentration of ABS in the WEEE matrix

4.1.2.Elongation at break

From Fig. 2 the elongation at break for each mixture is extracted and is reported in FIG. 5. It can be seen that this elongation increases as a function of the concentration of ABS in the WEEE matrix.

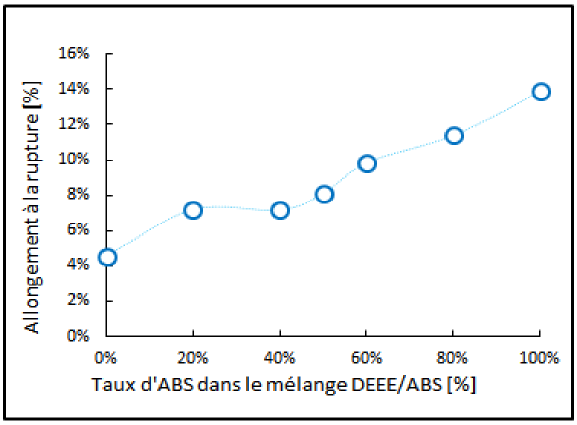


Fig. 5: Variation of the elongation at break of the mixtures in according to the concentration of ABS in the WEEE matrix

To better quantify these variations, we considered the rate of change of the elongations at break of the mixtures with respect to the elongation of the WEEE matrix that we define by the relation (1).

$$\Delta\varepsilon_{rupt} = \frac{\varepsilon_{rupt}^{DEEE+ABS} - \varepsilon_{rupt}^{ABS}}{\varepsilon_{rupt}^{ABS}} \qquad (1)$$

Figure 6 drawn from Figure 3 shows these variations well. It is noted that the mixture (80% WEEE / 20% ABS) gains 58.50% elongation at break with respect to that WEEE. The mixture (50% WEEE / 50% ABS) gains 78.15%.

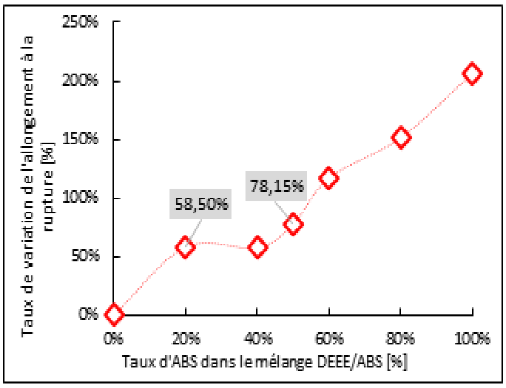


Fig. 6 : Variation rate of elongation at break of mixtures according to the concentration of ABS in the WEEE matrix

4.1.3. Elastic limit stress

From Figure 1 is extracted the maximum elastic stress for each mixture and reported in Figure 7. It can be seen that this stress increases considerably depending on the concentration of ABS in the WEEE matrix.

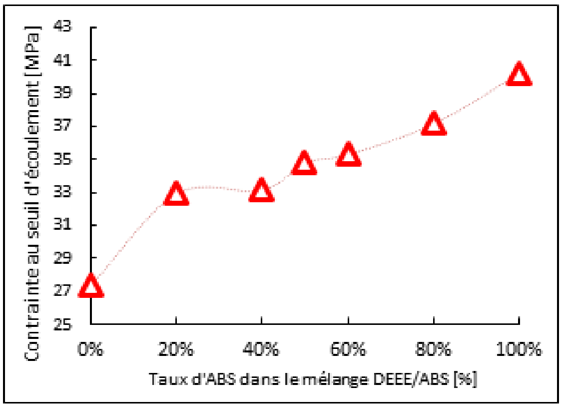


Fig.7: Variation of the maximum stress of mixtures according to the concentration of ABS in the WEEE matrix

To show this variation of the maximum elastic stress, we considered the rate of variation of this stress with respect to the maximum elastic stress of the ABS and that we represent in figure 8.

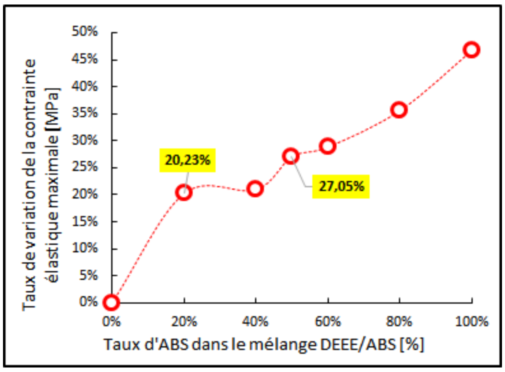


Fig.8: Rate of variation of the maximum stress of the mixtures as a function of the concentration of ABS in the WEEE matrix

Figure 8 shows that the mixture (80% WEEE / 20% ABS) gains 20% maximum elastic stress compared to that of WEEE. The mixture (50% WEEE / 50% ABS) gains 27%.

4.1.4. Resilience

The analysis of Figure 3 on variation in shock resistance shows that the addition of ABS to the WEEE matrix results in an increase in resilience. To better highlight and quantify these variations, we consider the rate of variation of this resilience compared to that of the WEEE matrix and that we define by the relation (2).

$$\Delta J_e = \frac{J_e^{\text{DEEE+ABS}} - J_e^{\text{DEEE}}}{J_e^{\text{DEEE}}} \qquad (2)$$

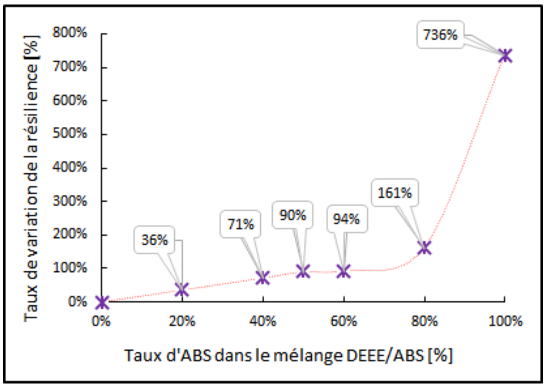


Fig.9 : Rate of variation of the resilience of the mixtures as a function of the ABS concentration in the WEEE matrix

Figure 9 drawn from Figure 3 shows these variations well. Thus this resilience gains 36% for a concentration of 20% of ABS in the WEEE matrix and reaches 90% for the mixture (50% WEEE / 50% ABS). We also note that virgin ABS is 7 times more resilient than the WEEE matrix.

4.2. Morphological characterization

Figure 10 (a) shows the fracture facies of the mixture (20% WEEE / 80% ABS). We note the presence of a continuous phase of styrene acrylonitrile (SAN) and a discontinuous phase (polybutadiene nodules grafted with styrene / acrylonitrile copolymers.) We also note the presence of particles of HIPS anchored in the SAN matrix.

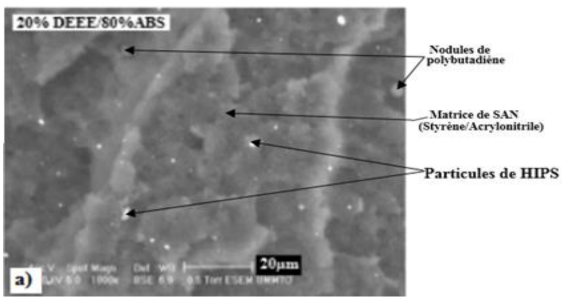


Fig. 10: Morphologies of the breaking facies of the mixture (20% WEEE / 80% ABS)

Figure 11 (a) shows the fracture facies of the mixture (40% WEEE / 60% ABS).

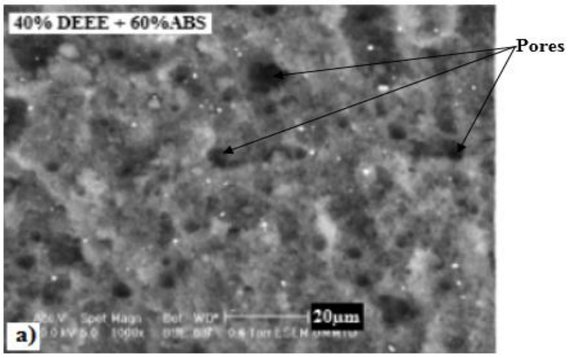


Fig. 11. Morphologies of the breaking facies of the mixture (40% WEEE / 60% ABS)

Pores are very visible and are due to the tearing of nodules of ABS and also to a bad degassing. This may explain the loss of resilience of blends compared to virgin ABS.

5. Conclusion

In this work we proceeded to the recovery of polymeric waste from the out of service electrical and electronic equipment. Knowing that one of the components of this equipment is ABS, we have chosen to add it to these WEEE at concentrations of 20, 40, 50, 60 and 80%. The samples test are made by injection process without additives and without accounting after cold mixing in a cylinder in random rotation and hot extrusion. Mechanical characterization through tensile tests showed a small variation in modulus of elasticity for all ABS concentrations in the WEEE matrix. The maximum elastic stress shows an improvement of 27% for a concentration of 50% of WEEE. Ductility shows a 50% improvement from the addition of 20% by weight of ABS to WEEE. As for the resilience it increases by 90% for the mixture (50% WEEE / 50% ABS). The analysis of tensile fracture facies micrographs revealed the existence of pores that are due to the removal of ABS nodules and also to poor degassing. This corroborates the results obtained for the reduction of the resilience compared to the virgin ABS.

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